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Radon, Passive Smoking, Particulates and Housing Epidemiology

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RESPIRATORY ILLNESS IN CHILDREN EXPOSED TO UNVENTED COMBUSTION SOURCES

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Abstract

Using a staged design of air quality monitoring, we followed 174 families using unvented kerosene heaters and 173 families without heaters for a three-month period to evaluate the association between nitrogen dioxide (NO_2) exposure and acute respiratory illness rates. Environmental and health data were obtained through personal interview, bi-weekly telephone interviews, tax assessor records, and from two-week integrated NO_2 measurements in 303 residences. One hundred-twenty-one children under age 13 were followed in this study, 59 living in homes with kerosene heaters and 62 living in homes without. Initial analyses indicate that exposed children have significantly more days of acute respiratory illness than controls. Limitations are imposed by sample size and by possible selection bias.

Introduction

Unvented combustion in homes can lead to high ambient levels of several air contaminants with nitrogen dioxide (NO_2) being the most notable (1). While NO_2 has been implicated as a potentiator of lower respiratory infections in laboratory animals (2), the epidemiologic evidence for determining unhealthy levels in humans is inconclusive at this time. Melia et al. (3,4) and Florey et al. (5) have reported data that suggest that children between the ages of 5 and 11 living in homes with gas cooking stoves had higher levels of acute respiratory symptoms or disease than those living in homes with electric cooking stoves. The range of NO_2 exposures measured in these studies was from 8–634 ug/m^3. The generalizability of these studies is limited by low

response rates and an overrepresentation of lower socioeconomic status groups.

Keller et al. (6,7) found no difference in illness rates between volunteers who lived in homes using gas for cooking and those using electricity. The range of NO_2 exposures in their study was reported for a sample of homes only and was very low (22 ug/m^3), so that it was unlikely that any positive association could be found. The potential for recall bias limits the finding of Speizer et al. (8) that children living in homes with gas cooking stoves had higher respiratory illness rates before age two than children living in homes using electricity stoves. Dodge (9) reported that exposure to parental smoking and gas cooking was associated with higher respiratory symptom rates in Arizona schoolchildren. However, his sample is unrepresentative, suffered from low response rates, and no pollutant measures were made.

The investigation reported here was designed to determine whether exposure to air contaminants emitted by kerosene space heaters, particularly NO_2, is associated with excess respiratory illness in children. We hypothesized that there was a positive correlation between NO_2 levels and acute respiratory illness rates among children. We identified a population with kerosene heaters where we could measure the household NO_2 exposures of children while accounting for many of the other potential risk factors for respiratory infections, such as parental smoking, presence of gas appliances, household size, school attendance, socioeconomic status, age, and previous history of respiratory infections.

Methods

Study Design and Population. To allow the most precise yet efficient estimation of individual exposures to pollutants, a staged design of air quality monitoring was employed in a cohort study. A cohort of adults who bought kerosene heaters was identified from lists obtained from local kerosene heater dealers in Connecticut. A control household was systematically chosen from the neighborhood of an exposed household. Neighborhood controls were selected to control ambient air quality and socioeconomic status. In each household an index woman, the oldest woman residing in the house, and an index child (if a child lived in the house), the child nearest in age to 5 but less than 13, were chosen to participate in the study. Households with no adult female present and households no longer using kerosene heaters were excluded from the study.

If subjects agreed to participate, an initial questionnaire was administered. Information was obtained about building characteristics, user heating patterns, and the health history and current respiratory symptomatology of the index adult and the index

child (if present). Subjects were then followed up by telephone bi-weekly for 12 weeks during January–March 1983 to obtain respiratory symptoms for the female and the child (if present) and heater use patterns during the previous two weeks period. As described in a separate paper (10) air monitoring for NO_2 was conducted for at least one two-week period in 87.3 percent of the study households. The study population analyzed here consists of 121 children under age 13. Fifty-nine lived in homes with kerosene heaters; 62 lived in homes without. All children were Caucasian.

Definition of Variables. The independent variables used in these analyses included: (1) demographic factors: age, sex, socioeconomic status [SES, Hollingshead Index(11)]; (2) exposure parameters: number of minutes of gas cooking per day (total estimated oven and burner use), number of cigarettes normally smoked daily at home by all residents, school enrollment, type of cooking fuel, total household size (a proxy for density), average daily hours of kerosene heater use for each two-week period, one two-week average measurement of NO_2 in each residence, and (3) respiratory illness history. "Respiratory illness history" was a continuous variable derived by adding each serious respiratory disease reported in the initial questionnaire (i.e. ever had pneumonia) and the average number of chest colds per year (estimated by the mother).

We used the reported average hours of kerosene heater use during each two-week period as a proxy for NO_2 exposure. Average hours of heater use (by household) correlates fairly well with integrated average NO_2 measurements ($r = 0.70$, $p < 0.001$). The variable, average hours of heater use, was available for each child for each of 6 periods.

The dependent variable used in multivariate analysis, days of illness, was not normally distributed, so we dichotomized it as one or more days of illness and no days of illness and used linear logistic regression following the methods of Harrell (12). SAS 82.3 programs were used for nonparametric analyses and the linear logistic regression. For variables that were normally distributed (i.e. age, household size, etc.), we computed means, t-tests, and correlations using StatPac (13) on the IBMPC.

Results

Participation and Demographic Factors. The household participation rate among the exposed group was 77.9 percent and 80.7 percent among the unexposed. The loss to follow-up over the study period was 3.4 percent among the exposed group and 5.7 percent among the unexposed.

There were no statistically significant demographic differences

between the exposed and unexposed groups of children. The mean age of the children studied was 6.8 years, the mean household size was 4.2 persons per household, the mean index of SES was 43.4, and the mean index of history of respiratory illness was 2.7.

Exposure Factors. There was more gas cooking in the unexposed children's homes (46.5 minutes/day) when compared to the exposed children's (17.5 minutes/day), t-test=1.82, $p = 0.07$, two-tailed; however, since so few children's homes had gas stoves (8 exposed, 13 unexposed), there were not enough data for meaningful use in the present analysis. There was no statistically significant difference in the mean number of cigarettes smoked daily in children's homes (12.63 exposed, 12.74 unexposed). Average two-week integrated NO_2 samples were taken in 113 of the 121 children's homes in four places: outdoors, in the kitchen, in a living room, and in an adult's bedroom. The mean outdoor level of NO_2 for exposed households was 14.62 ug/m^3 (range 5-43 ug/m^3) and 12.70 ug/m^3 (range 0-26 ug/m^3) for unexposed households. The mean kitchen level of NO_2 in homes with kerosene heaters was 46.92 ug/m^3 (range 3-211 ug/m^3) and 14.07 ug/m^3 (range 0-80 ug/m^3) in homes without kerosene heaters. The mean living room level of NO_2 in children's homes with kerosene heaters was 46.84 ug/m^3 (range 3-134 ug/m^3) and 10.36 ug/m^3 (range 0-63 ug/m^3) in children's homes without kerosene heaters. The mean level of NO_2 found in bedrooms in exposed homes was 46.82 ug/m^3 (range 3-225 ug/m^3) and 10.4 ug/m^3 (range 0-66 ug/m^3) in bedrooms in unexposed homes. The overall average use of kerosene heaters was 7.7 hours per day (range 0-24 hours per day). NO_2 measurements in children's homes with kerosene heaters were on average 3-4 times as high as in homes without heaters.

Association between exposure and acute respiratory illness. First, in order to determine whether kerosene heater exposure had an association with the days of illness, nonparametric statistical tests were applied to the data. Children exposed to kerosene heaters and children not exposed to heaters were ranked as to the total number of days sick over the 12 week follow-up period. A Wilcoxon rank sum test was performed using the t-approximation for the significance levels. Children living in homes with kerosene heaters had significantly more days of illness than children living in homes without kerosene heaters ($t=2.14$, $p < 0.05$).

Next, rank correlations were carried out between all independent variables and the dependent variable, days of illness. There was little association between average hours of heater use and number of days sick over the entire period (Spearman correlation coefficient, $r_s = 0.06$, $p = 0.09$). Age and history of respiratory illness were more strongly associated with days of illness ($r_s = 0.344$, $p < 0.01$ $r_s = -0.17$, $p < 0.05$, respectively).

Finally, linear logistic regression was used to determine which variables were significantly associated with one or more days of

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illness during each two-week period while adjusting for other measured potential risk factors. Average hours of heater use per day were significantly associated with days of illness ($p < 0.05$) while controlling for type of cooking fuel, cigarettes smoked per day, household size, sex, age, school enrollment, and history of respiratory illness. Age had a significant, inverse association with days of illness ($p < 0.05$). History of respiratory illness was positively associated ($p < 0.05$). SES was marginally associated ($p = 0.07$).

Discussion

This initial analysis suggests that young children with a history of respiratory infections are the most sensitive to the adverse health effects of NO_2 (or kerosene heater exposure). These results are consistent with previous studies that have shown that exposure to gas cooking has no effect on respiratory illness in women and school-age children (6,7), a borderline association with 5-11 year-olds (2,3,4) and an association with the history of respiratory illness in children under 2 years(7). The effects seem to be the most pronounced in young age groups. It should be emphasized that the results presented are preliminary.

These data are subject to many potential biases, some of which are: [1] recall bias in terms of reporting appliance use; [2] a limited ability to generalize from a convenience sample; [3] the publicity surrounding the safety of kerosene heaters; [4] all heater-owners had operated their heaters for at least one season prior to the study; as many as 34 potentially sensitive people were not eligible because they no longer used their heaters due to odor or hypersensitivity. A final limitation is the small sample size.

Further research should concentrate on studying the association between NO_2 exposure and younger-aged children.

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